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Characteristics of Hemodialysis Patients and Renal Transplant Recipients Undergoing Cardiovascular Intervention: Is It Possible to Predict Cardiac Risk?

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ABSTRACT

Introduction: Cardiovascular problems are one of the major causes of morbidity and mortality among renal transplant and hemodialysis patients. This study evaluates the preoperative risk factors and postoperative outcomes in patients undergoing heart surgery.
Methods: A total of 83 patients (47 post-renal transplant recipients and 36 on hemodialysis) who underwent cardiac surgery and percutaneous coronary artery procedures at Dr. Siyami Ersek Heart Hospital between 2015 and 2022 were retrospectively analyzed using hospital electronic records without selection bias. Demographic information, such as age, sex, height, weight, and body mass index, cardiac surgery type, and preoperative laboratory findings were recorded.
Results: Renal transplant recipients and hemodialysis patients undergoing heart surgery showed no significant differences in age, sex, or comorbidities ($P > 0.05$). Both groups had a high percentage of patients with elevated fasting blood glucose, triglycerides, and low-density lipoprotein levels. Additionally, body mass index and the triglyceride-glucose index were elevated, indicating insulin resistance. Renal transplant recipients with low preoperative glomerular filtration rate and hemoglobin levels < 10 g/dL had a higher risk of developing acute kidney injury. Four patients (9%) experienced graft loss after acute kidney injury, requiring hemodialysis. Mortality rates did not differ significantly between the groups ($P > 0.56$).
Conclusion: Cardiovascular surgery can be safely performed in both renal transplant recipients with functional allografts and end-stage kidney disease patients on hemodialysis. Identifying and managing risk factors in these patients, who frequently experience cardiovascular complications, will lead to better outcomes.
Keywords: Cardiac Surgical Procedures. Renal Dialysis. Acute Kidney Injury. Selection Bias. Insulin Resistance.

Abbreviations, Acronyms & Symbols

AKI	= Acute kidney injury	Hb	= Hemoglobin
AKIN	= Acute Kidney Injury Network	HD	= Hemodialysis
BMI	= Body mass index	HT	= Hypertension
CABG	= Coronary artery bypass grafting	LDL	= Low-density lipoprotein
CKD	= Chronic kidney disease	Ln	= Natural logarithm
CVD	= Cardiovascular disease	MMF	= Mycophenolate mofetil
CsA	= Cyclosporin A	PCI	= Percutaneous coronary intervention
DM	= Diabetes mellitus	Tac	= Tacrolimus
EF	= Ejection fraction	TG	= Triglycerides
ESKD	= End-stage kidney disease	TYG	= Triglyceride-glucose
GFR	= Glomerular filtration rate		

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INTRODUCTION

End-stage kidney disease (ESKD), which develops from chronic kidney disease (CKD) and has a high prevalence of cardiovascular disease (CVD), continues to be a major public health concern. Treatment options for patients requiring renal replacement therapy include kidney transplantation, hemodialysis (HD), and peritoneal dialysis. The most effective course of treatment for raising survival rates, quality of life, and life expectancy is kidney transplantation. Cardiovascular disorders include coronary artery disease, arrhythmias, heart failure, valve disease, pulmonary hypertension (HT), and peripheral vascular disease and are common in ESKD patients even after receiving a kidney transplant. Patients on dialysis and recipients of kidney transplants who experience cardiovascular morbidity have few alternatives for treatment.

CVD-related surgical treatment is becoming more and more common among patients undergoing renal transplants. These patients are often excluded from studies, and it's unclear what is the best revascularization plan for them. Even in the absence of optimal revascularization recommendations, routine measures such as percutaneous interventions and surgical procedures have been shown to improve the prognosis and symptoms of coronary artery disease. With improvements in organ preservation, immunosuppressive medications, and surgical procedures, cardiac surgery for recipients of renal transplants with functional allografts has shown satisfactory results, raising both the short- and long-term survival rates after surgery. In addition to assessing avoidable variables that raise cardiovascular risk, the study intends to investigate the preoperative and postoperative features of dialysis patients and renal transplant recipients undergoing heart surgery.

METHODS

A retrospective analysis was carried out on 83 patients (47 post-renal transplant recipients and 36 on HD) who underwent cardiac surgery and percutaneous coronary intervention (PCI) at Dr. Siyami Ersek Heart Hospital between 2015 and 2022. All patients over 18 years old with functional renal allografts diagnosed with coronary artery disease and who decided to undergo surgical or PCI as well as ESKD patients on regular HD treatment thrice weekly were included in the study. Patients under 18 years old and those who started dialysis after graft loss post-transplant were excluded. Surgical approach techniques were determined based on the surgeon's experience. Preoperative, intraoperative, and postoperative medical treatment and immunosuppressive medications for renal transplant patients were optimized by a nephrology specialist.

Data Collection

Retrospective analysis and recording from hospital electronic records without selection bias were done on the demographic data, including age, sex, height, weight, and body mass index (BMI), of the included renal transplant patients (n = 47) and ESKD patients receiving HD (n = 36). Information about the types of transplants performed on patients, the length of dialysis prior to the transplant, the immunosuppressive medications taken, the kinds of surgeries performed, and preoperative data were all documented. A review was conducted on the factors that determine the development of acute kidney injury (AKI) in patients receiving renal transplants, as well as the early mortality rates that occur in hospitals.

Surgical Procedures

Coronary angiography in renal transplant patients was performed at least 10 days before surgery as it is recommended. Standard surgical techniques (at the surgeon's discretion) were applied to all patients. All operations were performed under cardiopulmonary bypass. For myocardial protection, cold blood cardioplegia was used in all patients via the antegrade route. Throughout the procedure, great care was taken to make sure the mean blood pressure did not drop below 70 mmHg. For patients who needed it, medical inotropic support (such as noradrenaline and adrenaline) was administered both during and after surgery.

On the day prior to surgery, dialysis was administered to HD group. All the patients in the HD group received hemofiltration during surgery, and postoperative dialysis started on the first or second day following surgery.

Immunosuppressive Therapy

The patients' immunosuppressive medications remained unchanged. Intravenous steroid stress dosages were administered to all patients both before and following the onset of anesthesia. The immunosuppressive medications that were administered prior to surgery on the morning of the procedure were resumed orally as soon as possible after the procedure. Following surgery, the immunosuppressive medication regimen for each patient was carefully evaluated and changed based on serum drug levels.

Monitoring of Allograft Function

Standard preoperative tests were recorded, including serum sodium, potassium, urea, creatinine, complete blood count, and liver enzymes. Additionally, laboratory findings 24 and 48 hours after surgery were recorded.

Statistical Methods

The retrospective data were analyzed using IBM Corp. Released 2015, IBM SPSS Statistics for Windows, version 23.0, Armonk, NY: IBM Corp. software. Continuous variables were presented as mean ± standard deviation. Descriptive analyses were given using means and standard deviations. Percentage ratios were given for nominal and ordinal variables. The *t*-test was used for comparing quantitative data, and the chi-square test was used for comparing qualitative data. Multivariate analysis was performed for data comparison. Survival analysis was conducted using the Kaplan-Meier method. A *P*-value of < 0.05 was considered statistically significant during statistical analyses.

RESULTS

Between 2015 and 2022, a retrospective analysis was carried out on 36 patients with ESKD receiving regular HD three times a week and 47 renal transplant patients with functional renal grafts who had elective heart surgery. Table 1 summarizes the patient demographics distribution in both groups.

The average age of the dialysis group was 52.36 ± 8.708 years, and the transplant group was 49.51 ± 10.170 years at the time of admission. Table 1 shows that there was no significant variation in the two groups' smoking behaviors, sex, HT, hyperlipidemia, or

Table 1. Demographic distribution of renal transplant and hemodialysis patients undergoing cardiac surgery.

Characteristic	Renal transplant patients (n = 47)	Hemodialysis patients (n = 36)	*P*-value
Age (years)	49.51 ± 10.170	52.36 ± 8.708	0.251
Sex			0.46
Male	36 (59%)	25 (41%)	
Female	11 (50%)	11 (50%)	
Diabetes mellitus	17 (48.6%)	18 (51.4%)	0.206
Hypertension	36 (51.4%)	34 (48.6%)	0.027
Hyperlipidemia	22 (68.8%)	10 (31.3%)	0.78
Smoking	11 (55%)	9 (45%)	0.86
Body mass index			0.44
< 25	10 (53%)	9 (47%)	
> 25	37 (58%)	27 (42%)	
Ejection fraction			0.07
< 40%	6 (38%)	10 (62%)	
> 40%	41 (61%)	26 (39%)	
Primary kidney disease			0.03
Hypertension	20 (74.1%)	7 (25.9%)	
Glomerulonephritis	9 (75%)	3 (25%)	
Diabetes mellitus	8 (29.6%)	19 (70.4%)	
Polycystic kidney disease	3 (50%)	3 (50%)	
Kidney stones	2 (33.3%)	4 (66.7%)	
Vesicoureteral reflux	5 (100%)	0	
Mortality	10 (21.3%)	8 (22.2%)	0.56

presence of diabetes mellitus (DM). BMI did not differ statistically between the two groups; nevertheless, both groups had a higher percentage of overweight patients (BMI > 25) ($P < 0.44$). In terms of the etiology of kidney failure, HT accounted for the majority of cases (74.1%) in transplant patients, whereas DM was the main cause (70.4%) in HD patients. Although a slightly higher proportion of dialysis patients had an ejection fraction (EF) < 40 compared to transplant patients, the majority of patients in both groups had a left ventricular EF > 40 prior to surgery. Between the two groups, there was no discernible difference in postoperative mortality ($P > 0.56$).

The average preoperative laboratory values of the patients are summarized in Table 2, and comparisons of laboratory results between the groups are shown in Table 3.

Both groups had elevated average fasting blood glucose and triglyceride (TG) levels (Table 2). The triglyceride-glucose (TyG) index, a recognized predictor of insulin resistance and an important marker for coronary artery disease, was calculated using the formula: natural logarithm (Ln) (fasting TG [mg/dL] × fasting plasma glucose [mg/dL]/2). A TyG index above 4.49 was considered high, and significant values indicating insulin resistance were observed in both groups. High TyG index levels could explain the cardiovascular complications seen in these patients; however, prospective randomized controlled trials are needed for the early detection of major cardiovascular events. Preoperative albumin levels were significantly lower in dialysis patients compared to transplant patients. Postoperative hemoglobin (Hb) levels were significantly lower in dialysis patients than in transplant patients (Table 3).

Most patients underwent coronary artery bypass grafting (CABG) surgery due to coronary artery disease. CABG was significantly more common in HD patients compared to renal transplant patients ($P < 0.05$). As it is shown in Table 4, valve surgeries were more frequent in renal transplant patients ($P < 0.017$), with calcific aortic stenosis, mitral valve stenosis, and insufficiency being the most common etiologies.

Characteristics of renal transplant patients are shown in Table 5. The average age at transplant was 40.48 ± 11.04 years, and the average time between transplant and cardiac surgery was 8.82 ± 5.19 years. Most transplants were from live donors (72%). The average preoperative glomerular filtration rate (GFR) was 60.66 ± 23.07 mL/min, and the average postoperative GFR at 48 hours was 55.66 ± 26.85 mL/min. Tacrolimus (81%) was the most commonly used calcineurin inhibitor, and mycophenolate mofetil (82%) was the most commonly used antiproliferative drug. Eight patients (17%) used sirolimus, and all patients used corticosteroids.

Table 2. Preoperative laboratory values of transplant and dialysis patient groups.

Laboratory value	Renal transplant patients (n = 47)	Hemodialysis patients (n = 36)
Preoperative fasting blood glucose (mg/dL)	139.28 ± 60.42	142.31 ± 63.24
Preoperative triglycerides (mg/dL)	179.68 ± 73.92	207.86 ± 115.87
TyG index	4.97 ± 0.33	5.04 ± 0.37
Preoperative albumin (g/dL)	3.62 ± 0.44	3.57 ± 0.37
Preoperative hemoglobin (g/dL)	11.18 ± 2.09	11 ± 1.64
Preoperative LDL (mg/dL)	110.02 ± 32.64 (41 - 183)	114.36 ± 42.46 (45 - 213)
BMI	27.42 ± 3.53 (18.55 - 37.42)	28.53 ± 4.45 (20.76 - 38.14)

BMI=body mass index; LDL=low-density lipoprotein; TyG=triglyceride-glucose

Table 3. Preoperative laboratory comparison in transplant and dialysis patients.

Laboratory value	Renal transplant patients (n = 47)	Hemodialysis patients (n = 36)	*P*-value
Preoperative albumin (< 3.5 g/dL)	18 (43.9%)	23 (56.1%)	0.018
Preoperative hemoglobin (< 10 g/dL)	16 (57.1%)	12 (42.9%)	0.567
Postoperative hemoglobin (< 10 g/dL)	28 (45.2%)	34 (54.8%)	0.00
Triglycerides (> 150 mg/dL)	29 (55.8%)	23 (44.2%)	0.51
Fasting blood glucose (> 100 mg/dL)	32 (57.1%)	24 (42.9%)	0.54
LDL	110.02 ± 32.64	114.36 ± 42.46	0.42

LDL=low-density lipoprotein

Table 4. Distribution of surgical types and PCI in renal transplant and dialysis patients.

Procedure	Renal transplant patients (n = 47)	Hemodialysis patients (n = 36)	*P*-value
CABG	19 (46.3%)	22 (53.7%)	0.05
PCI	6 (60%)	4 (40%)	0.54
Valve surgery	19 (76%)	6 (24%)	0.017
Combined surgery	3 (43%)	4 (57%)	0.35

CABG=coronary artery bypass grafting; PCI=percutaneous coronary intervention

Definition of Post-transplant Acute Kidney Injury

The definition of post-transplant AKI was based on the Acute Kidney Injury Network (AKIN) classification, using serum creatinine levels. Data on urine output were not available. An increase in serum creatinine of > 0.3 mg/dL within 48 hours after surgery was defined as AKI. The preoperative serum creatinine level was considered the baseline.

There was no significant difference in sex between patients who developed AKI and those who did not (Table 6). Age distribution showed that the majority of both groups were over 40 years old. Patients with a BMI > 25 kg/m^2 were the majority in both groups, but there was no significant difference in the incidence of AKI. However, lower preoperative GFR and both preoperative and postoperative Hb levels were significant factors in the development of AKI. Patients with Hb levels below 10 g/dL preoperatively and postoperatively had a higher incidence of AKI. Although not statistically significant, preoperative high blood glucose levels showed a relatively higher incidence of postoperative AKI. Mortality rates did not show a significant difference between the groups presented in Table 7, but there was an observed higher mortality rate in patients who developed AKI. The number of stage 3 AKI patients requiring dialysis in the hospital and continuing dialysis upon discharge was four (14%).

DISCUSSION

The prevalence of ESKD is increasing worldwide, and with the rising life expectancy of patients at high risk for coronary heart disease, the number of patients benefiting from coronary revascularization

Table 5. Characteristics of renal transplant patients (n = 47).

Characteristic	Value
Age at transplant (years)	40.48 ± 11.04
Age at admission (years)	49.51 ± 10.170
Time between transplant and cardiac surgery (years)	8.82 ± 5.19
Pre-transplant dialysis duration (months)	32.06 ± 49.46
Type of transplant (live/deceased donor)	34 (72%)/13 (27.7%)
Preoperative GFR (mL/min)	60.66 ± 23.07
Preoperative creatinine (mg/dL)	1.52 ± 0.58 (0.63 - 2.90)
Postoperative GFR (48 hours) (mL/min)	55.66 ± 26.85
Postoperative creatinine (mg/dL)	1.76 ± 0.85 (0.50 - 4.06)
Immunosuppressive drugs used	
Calcineurin inhibitors (Tac/CsA)	38 (81%)/9 (19%)
Antiproliferative (MMF/azathioprine)	39 (82%)/2 (4%)
Sirolimus	8 (17%)
Corticosteroids	47 (100%)

CsA=cyclosporin A; GFR=glomerular filtration rate; MMF=mycophenolate mofetil; Tac=tacrolimus

Table 6. Characteristics of patients developing post-transplant AKI.

Characteristic	Postoperative GFR < 60 mL/min (AKI) (n = 28, 59.6%)	Postoperative GFR > 60 mL/min (no AKI) (n = 19, 40.4%)	*P*-value
Sex	Male: 21 (75%)	Male: 15 (78.9%)	0.52
	Female: 7 (25%)	Female: 4 (21.1%)	
Age	< 40 years: 6 (75%)	< 40 years: 2 (25%)	0.286
	≥ 40 years: 22 (56.4%)	≥ 40 years: 17 (43.7%)	
BMI (kg/m²)	< 25: 8 (28.6%)	< 25: 2 (10.5%)	0.131
	> 25: 20 (71.4%)	> 25: 17 (89.5%)	
Preoperative GFR < 60 mL/min	18 (82%)	4 (18%)	0.04
Preoperative Hb (g/dL)	Hb < 10: 14 (50%)	Hb < 10: 2 (10.5%)	0.05
	Hb > 10: 14 (50%)	Hb > 10: 17 (89.5%)	
Postoperative Hb (g/dL)	Hb < 10: 20 (71.4%)	Hb < 10: 8 (28.6%)	0.04
	Hb > 10: 8 (42.1%)	Hb > 10: 11 (57.9%)	
Preoperative blood glucose (mg/dL)	< 100: 11 (39%)	< 100: 4 (21%)	0.16
	> 100: 17 (61%)	> 100: 15 (79%)	
Mortality	8 (29%)	2 (11%)	0.131
AKI stage	Stage 1-2: 24 (86%) Stage-3: 4 (14%)		

AKI=acute kidney injury; BMI=body mass index; GFR=glomerular filtration rate; Hb=hemoglobin

is expected to rise as well. For patients who reach the stage of ESKD, kidney transplantation is considered the optimal treatment to improve life expectancy, quality of life, and survival. However, despite kidney transplantation, the cardiovascular risk remains high. CVDs continue to be the leading causes of mortality and morbidity in kidney transplant recipients due to the irreversible damage caused by years of renal dysfunction and dialysis[1]. Similarly, CVDs have been identified as the leading causes of morbidity and mortality among patients undergoing HD for ESKD when compared to the general population[2].

Table 7. Postoperative survival and mortality rates in renal transplant and dialysis patients.

Outcome	Renal transplant (n = 47)	Dialysis (n = 36)	*P*-value
Postoperative survival	33 (70%)	28 (78%)	0.97
Postoperative dialysis	4 (9%)		
Postoperative mortality	10 (21%)	8 (22%)	

The number of patients requiring surgical treatment due to cardiovascular morbidities in both kidney transplant recipients and dialysis patients is steadily increasing. Due to the limited number of small-scale studies with conflicting postoperative outcomes, cardiac surgery in kidney transplant recipients remains a topic of debate. However, recent evidence has demonstrated that surgical treatment can be applied safely with acceptable risk profiles and that good long-term survival outcomes can be achieved[3,4]. The strategy for surgical treatment must ensure good renal and cardiovascular outcomes. Yet, the optimal strategy remains uncertain for these patients with functional renal allografts, as well as for those with ESKD requiring dialysis. Due to their general exclusion from large cardiovascular outcome studies, there has been a lack of consensus regarding the management of CVD risk in patients with CKD and renal transplant recipients. Similarly, in patients with end-stage renal failure requiring dialysis, the optimal strategy for coronary artery revascularization remains a controversial issue[5]. Multidisciplinary cardiac teams have been shown to improve outcomes in transplant patients when the risks and benefits are thoroughly evaluated before making a decision regarding cardiac surgery[6]. Although CVD risk is lower in kidney transplant recipients compared to those who remain on dialysis, it is still high compared to the general population. Besides pre-existing pathologies before transplantation, post-transplant conditions such as new-onset DM, HT, dyslipidemia, obesity, anemia, and insulin resistance frequently contribute to cardiovascular risk factors. Effective management of these factors, which are thought to be partly influenced by immunosuppressive drugs, could potentially reduce the risk of CVD[1,2].

In our study, we compared the demographic characteristics, laboratory findings, and mortality rates of 47 kidney transplant recipients who underwent cardiac surgery (six patients received PCI) with 36 ESKD patients on dialysis (four patients were recommended for PCI). There was no significant difference between the two groups in terms of age, sex, presence of DM, HT, or hyperlipidemia ($P > 0.05$) (Table 1). Among kidney transplant recipients, HT (74.1%) was the most common underlying cause of kidney disease, whereas DM (70.4%) was the most common cause among dialysis patients (Table 1)[7]. Although there was no significant difference in mortality rates between the two groups, the in-hospital mortality rate following cardiovascular surgery in kidney transplant recipients was higher than the rates reported in the literature (21.3%). Herzog et al.[8] reported a 30-day mortality rate of 5% to 9.4% for patients undergoing coronary artery bypass surgery after kidney transplantation, while Rocha et al.[4] reported a rate of 12%. Another study indicated that 30 out of 170 patients with functional renal allografts who underwent cardiac surgery experienced either death or allograft failure within the first postoperative year (17.6%)[9]. There was no specific reason identified to explain the higher mortality rate observed in our study compared to the reported rates. When examining the type of surgical procedures, no significant difference was found between the two groups. In the distribution of surgical procedures, valve surgery was more commonly performed in renal transplant recipients (19 patients), and only three of these patients died. Among patients receiving HD, coronary bypass surgery was the most frequently performed procedure (Table 4). No significant difference was observed in mortality based on the type of surgical procedure. The causes of death in patients were sepsis, pneumonia, and hemorrhage.

Studies have demonstrated that kidney transplantation significantly improves EF in patients with systolic heart failure and ESKD. The improvement is primarily due to the reversal of the negative myocardial effects of long-term dialysis, including the correction of anemia, resolution of secondary hyperparathyroidism, normalization of renin-angiotensin-aldosterone system activity, and the removal of uremic toxins. These changes lead to substantial enhancements in cardiac structure and function, ultimately improving survival rates. Consistent with numerous studies that have shown significant EF recovery after transplantation, our findings also indicated that preoperative EF values were better in transplant recipients compared to those on dialysis[10-12].

We assessed risk factors affecting post-transplant cardiovascular morbidity and mortality, including average blood glucose, TG, low-density lipoprotein levels, and the TyG index, an objective measure of insulin resistance (Table 3). The TyG index has been associated with major cardiac events in various studies, including those involving kidney disease patients[13]. In both groups, the preoperative TyG index measurements (Ln [TG [mg/dL] × fasting glucose [mg/dL]/2]) were above the reported cutoff value of 4.49. Additionally, although guidelines recommend a low-density lipoprotein cholesterol level of < 70 mg/dL for kidney transplant recipients, our patients had levels higher than the target of < 100 mg/dL for those with moderate cardiovascular risk. All patients planned for surgery due to cardiovascular morbidity had high blood glucose levels, dyslipidemia, and insulin resistance. Effective management of these modifiable risk factors could be a viable strategy to reduce cardiovascular risk[13-16].

Obesity, another significant and modifiable risk factor for cardiovascular system diseases post-transplantation, is reported to occur in 30-35% of patients within five years of transplantation. In our study, the mean BMI was 27.42 ± 3.53 kg/m^2 in transplant patients and 28.53 ± 4.45 kg/m^2 in dialysis patients. The BMI in transplant recipients exceeded the cutoff value for cardiovascular risk (23 kg/m^2). The finding of overweight status in patients undergoing surgical treatment is significant for cardiovascular risk development and suggests the need for close monitoring of metabolic syndrome[17].

Chronic anemia, one of the factors contributing to cardiovascular structural abnormalities in dialysis patients, is typically corrected after kidney transplantation. However, this unconventional risk factor, when anemia develops post-transplant, has been shown to increase the severity of CVDs such as coronary artery disease, peripheral arterial disease, and heart failure[18,19]. In our study, the average Hb level in renal transplant recipients was found to be 11.18 ± 2.09. There was no significant difference compared to CKD dialysis patients. There are conflicting results regarding whether the presence of anemia in transplant recipients contributes to the development of cardiovascular morbidity and what the optimal Hb level should be. In our study, we observed low post-transplant Hb levels. This low value may contribute to cardiovascular morbidity, but further comprehensive and prospective studies are needed to clarify this issue[20-22].

Studies have shown that there is an increased risk of AKI after cardiac surgery in renal transplant recipients[23]. In our post-transplant cohort, 28 patients (59.6%) developed AKI after heart surgery. Among these, 24 patients (86%) experienced stage 1 or 2 AKI, while four patients (14%) developed stage 3 AKI. The incidence of AKI in our study was higher than the reported rate in the literature (46%). No significant differences were observed between patients with and without AKI in terms of age, sex, BMI, or preoperative blood glucose levels. However, patients with preoperative low GFR and those with preoperative and postoperative Hb levels < 10 g/dL had a significantly higher incidence of AKI. Among those who developed AKI, eight patients (29%) died. These patients who died after AKI had prolonged intensive care unit stays, were unable to be weaned off mechanical ventilation, had poor wound healing, and suffered from severe infections (Table 6).

Early postoperative survival rates were similar to those reported in the literature, with a survival rate of 70% for transplant patients and 78% for dialysis patients, comparable to the 78.9% one-year survival rates reported (Table 7)[24]. Four patients (9%) experienced graft loss and subsequently required regular HD.

Limitations

Our study is retrospective and limited to a single institution. The assessment and accuracy of the data relied on the information from medical records. As a non-randomized study, our follow-up period post-transplantation was insufficient for evaluating long-term outcomes. Since only short-term postoperative results were investigated, we believe that improving current results with a prospective study could benefit patient management in kidney diseases, which are one of the fundamental pathologies affecting cardiovascular health.

CONCLUSION

In patients with kidney transplants and HD who carry a substantial CVD burden, many traditional and non-traditional risk factors have been identified. In our study, which assessed preoperative cardiovascular risk factors and surgical outcomes in kidney transplant recipients with functional allografts and HD patients undergoing cardiac surgery, we found elevated blood glucose, high lipid levels, insulin resistance, and the presence of obesity in these patients. To improve cardiovascular risk management and treatment outcomes in this group, more effective strategies need to be developed. We believe that appropriate management of these risk factors can reduce the prevalence of CVD.

Cardiac surgery is a feasible treatment option for kidney transplant recipients with functional allografts and HD patients, with manageable mortality and morbidity rates. Additionally, we think that positive results in terms of early mortality and long-term survival can be achieved in HD and post-transplant patients requiring cardiac surgery.

As cardiac surgical techniques advance, along with increased surgical expertise and better recognition and management of risk factors, we expect improved surgical pathways and post-treatment outcomes for these patients. However, more extensive prospective randomized controlled studies are needed to evaluate surgical treatment in patients with CVDs, which are a major cause of morbidity and mortality among post-transplant and HD populations.

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Authors' Roles & Responsibilities

DAK	Substantial contributions to the conception of the work; and the acquisition of data for the work; drafting the work
FK	Substantial contributions to the conception of the work; and the analysis of data for the work; drafting the work
RG	Substantial contributions to the design of the work; and the analysis of data for the work; drafting the work
BK	Substantial contributions to the acquisition of data for the work; revising the work

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